Climate Change Adaptation Planning, Implementation, and Evaluation: Needs, Resources, and Lessons for the 2013 National Climate Assessment

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Cover photo credit: Getty Images/Jonathan Wood – 2011 Flooding in Rockhamton, Australia

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Executive Summary

Climate change adaptation is the subject of increasing attention from American government bodies and the general public, yet activity to respond to the impacts of climate change remains in its nascent stage. Adaptation initiatives to date are often inefficient due to a lack of coordination exacerbated by the inherently local nature of climate change impacts and adaptation requirements. To improve this situation, effort must be made to unite bottom-up needs and experience with top-down resources and guidance. The 2013 National Climate Assessment represents an important opportunity to communicate the current state of climate adaptation knowledge and practice to the federal government, consolidate key resources, and encourage increased communication, coordination, and evaluation by adaptation leaders and practitioners from the local to the national levels. This report synthesizes present adaptation resource needs, guidance tools, current practices, and evaluation methods to develop recommendations and identify essential areas of research for the federal government to effectively address climate change adaptation.

Community Adaptation Resource Needs

Despite high community government interest in engaging in adaptation planning, significant financial, informational, and institutional resource needs have deterred progress. Given the poor economy, funding is a central hurdle for adaptation action, requiring the development of more robust justification of investments today. Increased capacity to interpret scientific data and additional fine-grained information are necessary to make the science of climate change "actionable" at the local scale. Tools to complete and implement adaptation plans are also important, particularly those which facilitate decision making despite the uncertainty inherent in climate projections. Governments seek methods to integrate adaptation planning throughout their operations and evaluate the outcomes of their actions. Communication both internal and external to communities is also necessary to generate support for climate adaptation. Streamlined channels are needed to improve resource exchanges between and within sub-national government bodies and the federal government. Consolidation of needs through aggregation can help increase the efficiency of access to resources, while a greater emphasis on training and capacity building can help communities meet their own adaptation requirements.

Climate Change Adaptation Planning Guides

Current guidance for adaptation planning and implementation can be divided into three categories: step-by-step, adaptation principles, and examples and resources. Step-by-step guides provide detailed, sequential checklists for governments to complete adaptation plans. Their specific nature increases the likelihood of concrete results, though guidance for implementation and evaluation of plans is inconsistent and therefore a key barrier to effective outcomes. Adaptation principles guides are less structured in their discussion of characteristics that make up a successful adaptation plan. This increases their generalizability but decreases direct utility; they

provide a good basis for evaluating adaptation planning processes or developing new step-by-step guides. Examples and resources guides list multiple case studies and thorough resources, but generally lack concrete procedural guidance. Online databases fall into this category, which is best suited to supplement the preceding guide types.

Guides can be evaluated based on their depth of information and ease of implementation for their intended users. Due to the diverse range of adaptation planning needs and capacity, however, it may be more useful to provide governments with a mechanism to select multiple guides that are most appropriate for their circumstances rather than rate guides independently.

Current Practices in Adaptation Planning and Implementation

Most state and local governments that are addressing climate adaptation are in the preliminary planning stages, and those plans that do exist are generally not judged to be very thorough. Communities' perceived lack of capacity to implement adaptation actions reiterates the need for better informational and decision making tools. Two case studies of effective government adaptation planning illustrate the value of mainstreaming and aggregation as adaptive strategies:

Keene, NH is a small town with a significant history of climate mitigation initiatives and a strong partnership with ICLEI. Following ICLEI's "Five Milestones" technique, Keene successfully developed a thorough adaptation plan in 2007. Keene is notable for having fully integrated its adaptation plan into its 2010 master plan, increasing the likelihood of action implementation by mainstreaming adaptation plan goals into overall municipal operations.

The 2009 Southeast Florida Regional Climate Change Compact represents a collaborative approach between four Florida counties to address climate change. By pooling their resources, the Compact members increased their capacity to address local needs and created a unified voice to advocate for state and federal support, as well as a single point of contact for this assistance.

Evaluation of Adaptation Planning and Implementation

Vigorous, standardized monitoring and evaluation of climate adaptation planning and implementation is largely deficient. Given the early stage of most adaptation initiatives, it is particularly important to distinguish adaptation processes from outcomes and ensure that these processes are robust and adaptive in nature. Consideration of local circumstances and assumptions is necessary to accurately compare the effectiveness of adaptation plans between communities, while establishment of adaptive management goals and resilient community characteristics can serve as more universal baselines of evaluation. Improvement of adaptation evaluation, including monetization, is important to justify future activity.

Climate Change Adaptation in Federal Agencies: The Environmental Protection Agency

Among federal agencies completing the CEQ-mandated adaptation planning process, the EPA has made significant progress in responding to climate change, with action corresponding to each of the four preceding subjects. The EPA has acknowledged climate change as a threat to its core mission and set a goal of mainstreaming adaptation considerations throughout the agency. It has developed internal guidelines to achieve these goals as well as step-by-step tools available for external use. EPA's five-year strategic plan identifies climate change impacts as a central concern and has led to mandates to create agency-wide and program-specific adaptation plans. The strategic plan's performance goals will be evaluated based on the consideration of climate impacts in the development of new tools, regulations, and funding mechanisms. The EPA has created additional plans and metrics to evaluate the adaptation planning processes within EPA programs, with the potential to be applied across all federal agencies.

Conclusions: Key Adaptation Tasks and Resources for the 2013 NCA

The significant breadth of resources encompassed by this synthesis indicates the importance of the federal government's provision of organization and linkages to promote climate change adaptation activity at all levels of government. This could be enabled by a National Climate Service or similar body which would act as an agent to create and monitor data and connect local government bodies to relevant adaptation resources. It could also serve as a unifying conduit of federal adaptation activities to ensure clear communication and consistency.

Aggregation and mainstreaming are two practices in adaptation planning and implementation that have proven effective to help bridge the gap between top-down resources and bottom-up needs. Local governments also play an important role in laying the groundwork for effective climate adaptation. Communities can collect data on current weather conditions and extreme events, build internal support and establish responsibility networks between jurisdictions, and reach out to peers and non-governmental organizations to build coalitions and increase capacity.

Future research needs include more systematic description of available guidance resources and the formation of tools to connect them to local governments, deeper analysis of monitoring and evaluation systems and definition of climate resilience, and development of efficient means of sharing lessons learned and best practices between government bodies. This continual process of learning and adjustment is ultimately integral to an adaptive society.

1 Introduction

Adaptation to climate change is being paid increasing attention as progress towards global agreements to limit greenhouse gas emissions moves slowly and climate change impacts are more frequently recognized in today's weather events around the globe. Having been perceived as either-or options in the past, mitigation and adaptation strategies are now considered to go hand-in-hand in the necessary effort to "avoid the unmanageable and manage the unavoidable."[1] Beyond leaders in climate change policy, general support for action to adapt to climate change has become increasingly widespread. In a May 2011 survey of public support for climate and energy policies, Yale and George Mason researchers found a significant majority of respondents consider "protecting local assets [such as water supply, public health, and agriculture] from global warming" to be important.[2] Furthermore, many respondents see global warming as an immediate threat and a majority foresee it to be a threat in the future, expressing specific concerns over negative impacts from extreme weather events, increased spread of disease, and direct heat exposure.[3]

Many government bodies at the local, regional, state, and federal level across the United States have already begun preparing to adapt to the impacts of climate change.[4] However, thus far there has been little coordination between their efforts to plan and implement adaptation measures, leading to inefficient use of resources and inconsistent results as each body goes through the process independently, with little ability to compare effectiveness.[5] Some of these challenges stem from key differences between climate adaptation and mitigation: whereas mitigation strategies can be largely generalized across spatial and hierarchical levels of government, adaptation by definition requires responding to distinctly local impacts. Adaptation needs vary widely between a small New England community such as Keene, NH and a large, coastal city such as Miami, FL, and—unlike mitigation—efforts in one area generally do not contribute to benefits realized in other parts of the country and globe. The local nature of adaptation thus places unique demands on local government bodies which, in many cases, are the least likely to possess the resources necessary to respond to these demands.

Therefore, it is crucial that federal support for climate change adaptation has the goal of uniting bottom-up needs and existing efforts with top-down resources and coordination. While evidence suggests that communities are largely unable to tackle adaptation planning and implementation on their own, generalized external mandates and resources are unlikely to be

effective or welcomed.[6] Integrating centralized resources with a participatory approach which allows for local stakeholder input and engagement is therefore key to the success of a national adaptation program.[7]

The 2013 National Climate Assessment (NCA) is faced with a valuable opportunity to facilitate significant progress in the essential area of climate change adaptation. The Assessment should address the current state of practice, consolidate vital resources, and encourage increased communication, coordination, and evaluation by adaptation leaders and practitioners from the local to the national levels. Framing adaptation initiatives as a union between bottom-up needs and top-down resources will greatly increase the likelihood of achieving more effective outcomes.

This report will inform this opportunity by synthesizing important knowledge and trends in US climate change adaptation. Section 2 further elaborates on key challenges facing local government bodies working to adapt to climate change and needs to address these challenges. Section 3 discusses current resources available to guide adaptation planning and implementation and potential strategies to compare and evaluate these guides. Section 4 provides a snapshot of current adaptation planning practices, focusing on two case studies of very different approaches to adaptation being undertaken in Keene, NH and southeast Florida. Section 5 surveys current methods of evaluating adaptation planning processes and implementation outcomes and addresses shortfalls and alternative strategies in both of these areas. Section 6 provides a case study of the Environmental Protection Agency as an example of a federal agency that has displayed leadership in addressing climate change adaptation, in the process contributing to the understanding of needs, guidance, plans, and evaluation discussed in the preceding sections. Finally, the conclusion addresses key lessons drawn from the analysis and identifies specific climate adaptation tasks for the NCA, as well as recommendations for future research. Appended are thorough, though not exhaustive, annotated lists of resources aligned with each of the four major report sections.

Research for this report was an iterative process centered on interviews with key thinkers and practitioners in the field of climate adaptation, including representatives from academic, government, and non-profit institutions (see Appendix 5 for full list of interviewees). Given the nascent character of climate change adaptation practices, these conversations were particularly useful to glean the current state of knowledge in the domain. Interviewees were also asked to

identify important resources which form the literature basis for this report and its appendices. The scope of the report is primarily limited to the US, though some resources apply to international circumstances, and the report focuses primarily on governmental adaptation practices in the small to medium-sized communities that are most in need of support. Therefore, non-governmental organization approaches to adaptation and well-known cases such as New York City and Chicago are not addressed in depth here.

2 Community Adaptation Resource Needs

Community governments across the US are expressing strong interest in preparing to adapt to the impacts of climate change. In a survey of its 578 member communities, ICLEI found that of 298 respondents, 59% report engaging in some form of adaptation planning.[8] Key motivations for these actions include "being prepared for the future," "advancing community livability," and "reducing impacts from natural hazards."[9] However, the inherently local nature of climate adaptation remains a significant hurdle for all levels of government response. A lack of readily available information of local projected climate impacts inhibits adaptation risk assessment and decision making, while a lack of local resources and capacity inhibits planning and implementation processes. Interviewees and the literature identify four core resource needs at multiple scales for successful community adaptation: funding, information, tools, and communication. Many of these needs reflect the conclusions reached in the 2010 National Adaptation Summit (see *Box 1*)[10].

2.1 Funding

Lack of funding for adaptation initiatives is a clear issue, particularly in the current economic situation. Of the ICLEI survey respondents, 89% identify funding as a "major challenge" for adaptation, while 87% identify allocating staff time and reallocating existing resources to be major challenges.[11] Work to evaluate the future benefits of present investments in adaptation activity (see Section 5) is essential to build on the success of some channels, such as the UNFCCC conferences, to establish financing for climate adaptation.[12] A number of adaptation guides prioritize the selection of "no-regrets" or "low-regrets" actions to help warrant expenditures.[13] The former are strategies which will assist in adapting to climate change but can be justified even in the absence of climate change, such as reforming insurance regulation to

Box 1: Conclusions from the National Adaptation Summit

- One size doesn't fit all--
  - Ø but we all need similar kinds of information
- Providing access to data is not the same as providing "usable" data--
  - Ø need a useable 'portal' into the Federal data and translators to help us answer the right questions
- Need a roadmap to the Federal enabling activities--
  - Ø how do the (very promising) Federal centers, initiatives, strategies fit together
- Improved downscaled information is helpful--
  - Ø but is not a reason to delay adaptation efforts
- Need help in analyzing the costs of adaptation--
  - Ø and the costs of NOT adapting; including understanding "additionality"
- Initiate a series of pilot projects to explore adaptation actions and effectiveness at multiple scales--
  - Ø part of the new assessment process?
- Need a clearing house of 'best practices'--
  - Ø and toolkits that exist
- Need standardized and certified gov data
  - Ø sea level rise, extreme events, water, heat stress
  - Ø approaches to downscaling, how to use appropriately
- Need social and biophysical data layers that help identify hotspots--
  - Ø such as the intersection of urban heat island effects, CSOs, indicators for economic vulnerability like foreclosure areas
- Need a process for updating data regularly --
  - Ø 'one-offs' don't help
- New ways of thinking about adaptation--
  - Ø e.g., we have "snow days", may need to think about "flood days"
- Regional planning for adaptation--
  - Ø provides huge benefits
- Sharing implementation experience and technology transfer--
  - Ø will improve efficiency of planning and implementation
- Need information on socio-economic changes likely over time--
  - Ø such as demographics, employment, etc., in addition to climate data
- An adaptation fund would help--
  - Ø can help jumpstart activities
- Assessment should focus on progress in mitigation and adaptation systems--
  - Ø and their intersection

enable rates to better reflect risks. The latter are strategies that are predicated on the climate changing, but are relatively low in cost, such as raising a flood barrier in anticipation of future sea level rise.[14] These approaches also help mitigate decision uncertainty, discussed below in Section 2.3.

2.2 Information

In order to adapt to climate change, communities must be able to understand how they are likely to be affected by climate change and how these impacts are likely to change over time.[15] One central challenge is providing impact projections at appropriate levels of detail, as many of the current climate model projections are on a national or regional level that is too course-grained for effective local use.[16] "Downscaling" is thus a common demand so that communities can project the impacts for their specific location. Beyond access to more detail, however, local governments also need support to interpret the science so that it becomes "actionable" at the local level.[17] Otherwise, even the most detailed data may not be sufficient to drive adaptation processes. ICLEI's survey findings that communities perceive obtaining information as a somewhat lower challenge ("major challenge" for ~50%)[18] reinforces the potential disconnect between the data that is available and that which is actually usable in adaptation planning and implementation processes. Communities such as Keene have partnered with local universities to help interpret scientific data,[19] an effective means of translation. Not all communities, however, have access to such partnerships. Increasing local capacity to uptake scientific information by facilitating academic partnerships while developing central services to translate data to improve its accessibility can help lower the barrier of local scientific literacy.[20]

2.3 Tools

Community governments have also expressed a need for improved adaptation tools. While a number of adaptation guides exist (see Section 3), more explicit and consistent guidance for adaptation planning processes is necessary. Many of the current guides are too high-level, and do not provide explicit instruction in methods of decision analysis, consideration of institutional roles and capacity, and political and social acceptance.[21] Decision making processes are in particular need of greater support. Connected to informational needs, many governments struggle to evaluate conflicting information and address high levels of uncertainty.[22] Guidance is necessary to allow for action despite such uncertainty, which is inherent in the predictive nature

of climate change. Once a list of potential adaptation actions is identified, governments need consistent metrics to help evaluate and prioritize these options to avoid being overwhelmed.[23] Economic evaluation tools may be helpful for this process,[24] as well as the "no-regrets/low-regrets" framework described above. Many communities are also interested in integrating adaptation planning into general planning practices, but are lacking tools for such "mainstreaming" approaches;[25] the Keene case study in Section 4 will provide an example of how this has been accomplished successfully. Finally, communities must have tools to evaluate the effectiveness of adaptation planning and implementation efforts.[26] Discussed in more detail in Section 5, consistent performance measures will help government bodies determine the effectiveness of their actions and justify additional steps.[27] However, given the diverse nature of communities, such evaluation must also be customizable to the unique circumstances of each one.

2.4 Communication

Improved communication will help provide a consistent definition of "climate change adaptation" to be applied across government jurisdictions, stakeholders, and practitioners.[28] Once a common understanding is established, it is essential to develop increased support for adaptation initiatives among stakeholders both internal and external to governing bodies.[29] ICLEI's survey indicated significant challenges in getting people to understand the problem of climate adaptation (71% "major challenge"; 28% "some challenge") and in generating interest in adaptation among businesses (78%; 22%).[30] Slightly less challenge (~60%; 30%) was reported in generating interest and getting commitment from public officials and staff to address climate change adaptation.[31] One key area of improvement for federal institutions is to improve coordination between agencies and streamline communication with communities regarding climate adaptation to minimize confusion due to multiple sources of sometimes conflicting information.[32] Providing a single access point of information (such as www.climate.gov; see Conclusion) and regular information updates will help streamline federal-stakeholder communication and reduce uncertainty.[33] Policy directives from the federal government are also important to incentivize local action.[34] Pilot programs such as ICLEI's Climate Resilient Communities can provide effective models and generate increased interest and awareness in participation, particularly when supported by competitive grants.[35] Lastly, communities seek more streamlined

mechanisms to share information and collaborate with peers.[36] Case studies are particularly helpful to illustrate adaptation lessons;[37] while many of these are available in online databases,[38] more effort could be made to simplify and increase awareness of these resources.

2.5 Consolidation of Needs

In addition to addressing needs individually, it is worth considering means of efficiently consolidating community adaptation requirements. The Southeast Florida Regional Climate Change Compact, discussed in detail in Section 4, attempts to do this by aggregating local needs to the regional level and then providing a single point of contact for state and federal support.[39] Also, the ICLEI surveyors conclude that improved communication could bridge the gap between stakeholders and resources by increasing the accessibility of adaptation guidance and tools and fostering collaboration to address common challenges.[40] Finally, a greater emphasis on training and capacity building by the federal government may increase communities' ability to meet their own needs.[41]

3 Climate Change Adaptation Planning Guides

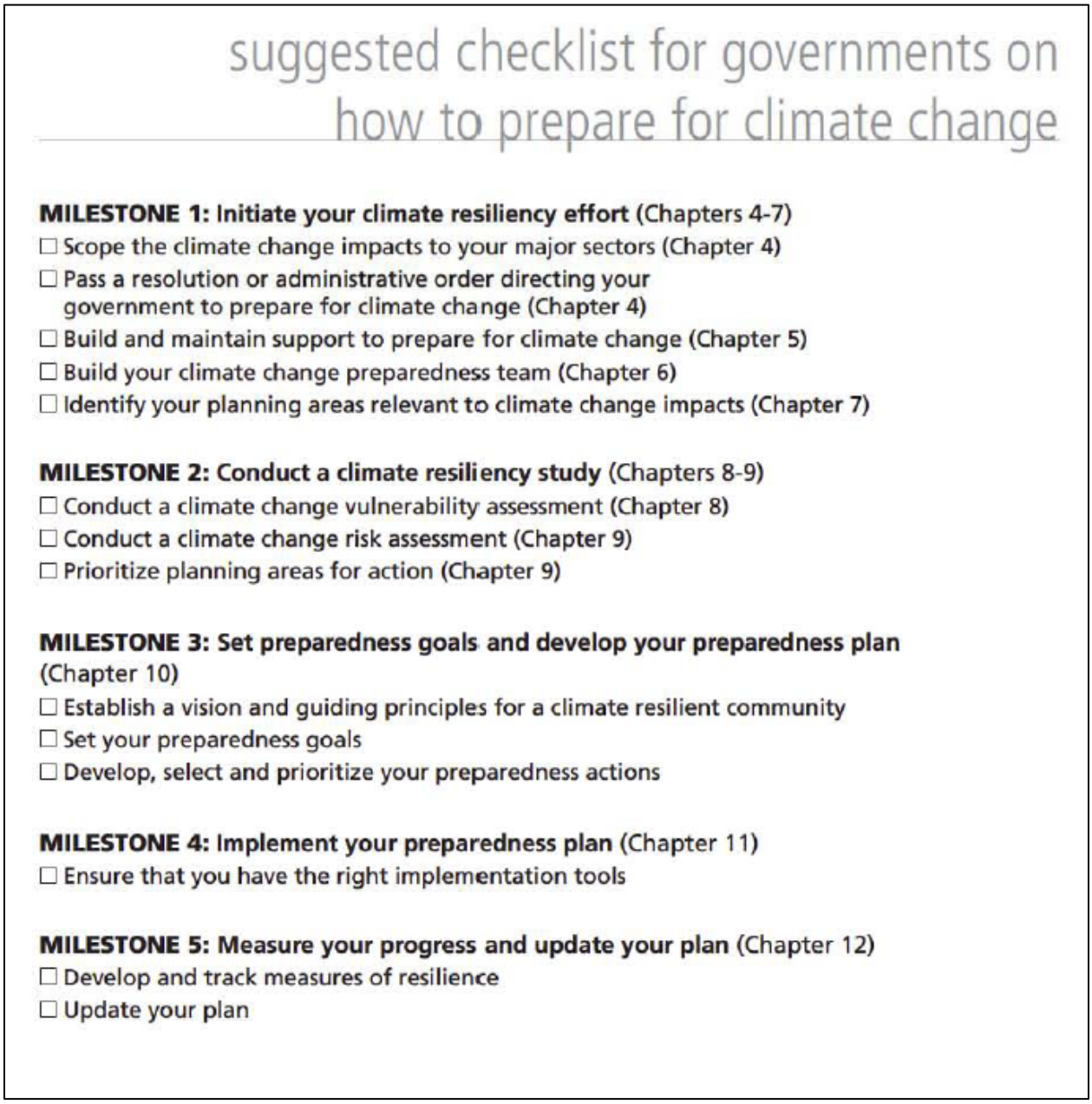
Significant guidance for government adaptation planning currently exists. These guides strive to address a number of the needs listed above, particularly in providing tools. However, guides vary widely in depth and approach. The handful of guides sampled for this report can be divided into three categories: step-by-step, adaptation principles, and examples and resources.

3.1 Step-by-step

Step-by-step guidance is the most detailed, providing stepwise actions for a government body to develop and, ultimately, implement an adaptation plan. The most well-known of these guides is *Preparing for Climate Change: A Guidebook for Local, Regional, and State Governments* composed in 2007 through a collaborative effort between the University of Washington Climate Impacts Group, ICLEI, and King County, WA.[42] Centered around "Five Milestones" developed by the ICLEI Climate Resilient Communities program (see *Figure 1*)[43], the guidebook provides a checklist to help governments carry out adaptation planning by building community and institutional support, developing an adaptation plan based on a vulnerability assessment and prioritized goals, and implementing, evaluating, and adjusting that

plan. Each step is accompanied by sample materials to model appropriate actions, lists, and analyses. The planning guide is supplemented by background information on climate science and reasons for a government to act, case studies of existing community adaptation plans, lists of sample adaptation actions across sectors, basic information on climate science and impacts across national regions, and lists of additional resources. Thanks to ICLEI's widespread network, this guidebook has been used by many cities across the country, with positive anecdotal feedback. A more formal evaluation is currently in process by ICLEI.[44]

Figure 1: CIG/ICLEI/King County adaptation planning guide checklist



suggested checklist for governments on how to prepare for climate change

MILESTONE 1: Initiate your climate resiliency effort (Chapters 4-7)
- ☐ Scope the climate change impacts to your major sectors (Chapter 4)
- ☐ Pass a resolution or administrative order directing your government to prepare for climate change (Chapter 4)
- ☐ Build and maintain support to prepare for climate change (Chapter 5)
- ☐ Build your climate change preparedness team (Chapter 6)
- ☐ Identify your planning areas relevant to climate change impacts (Chapter 7)

MILESTONE 2: Conduct a climate resiliency study (Chapters 8-9)
- ☐ Conduct a climate change vulnerability assessment (Chapter 8)
- ☐ Conduct a climate change risk assessment (Chapter 9)
- ☐ Prioritize planning areas for action (Chapter 9)

MILESTONE 3: Set preparedness goals and develop your preparedness plan (Chapter 10)
- ☐ Establish a vision and guiding principles for a climate resilient community
- ☐ Set your preparedness goals
- ☐ Develop, select and prioritize your preparedness actions

MILESTONE 4: Implement your preparedness plan (Chapter 11)
- ☐ Ensure that you have the right implementation tools

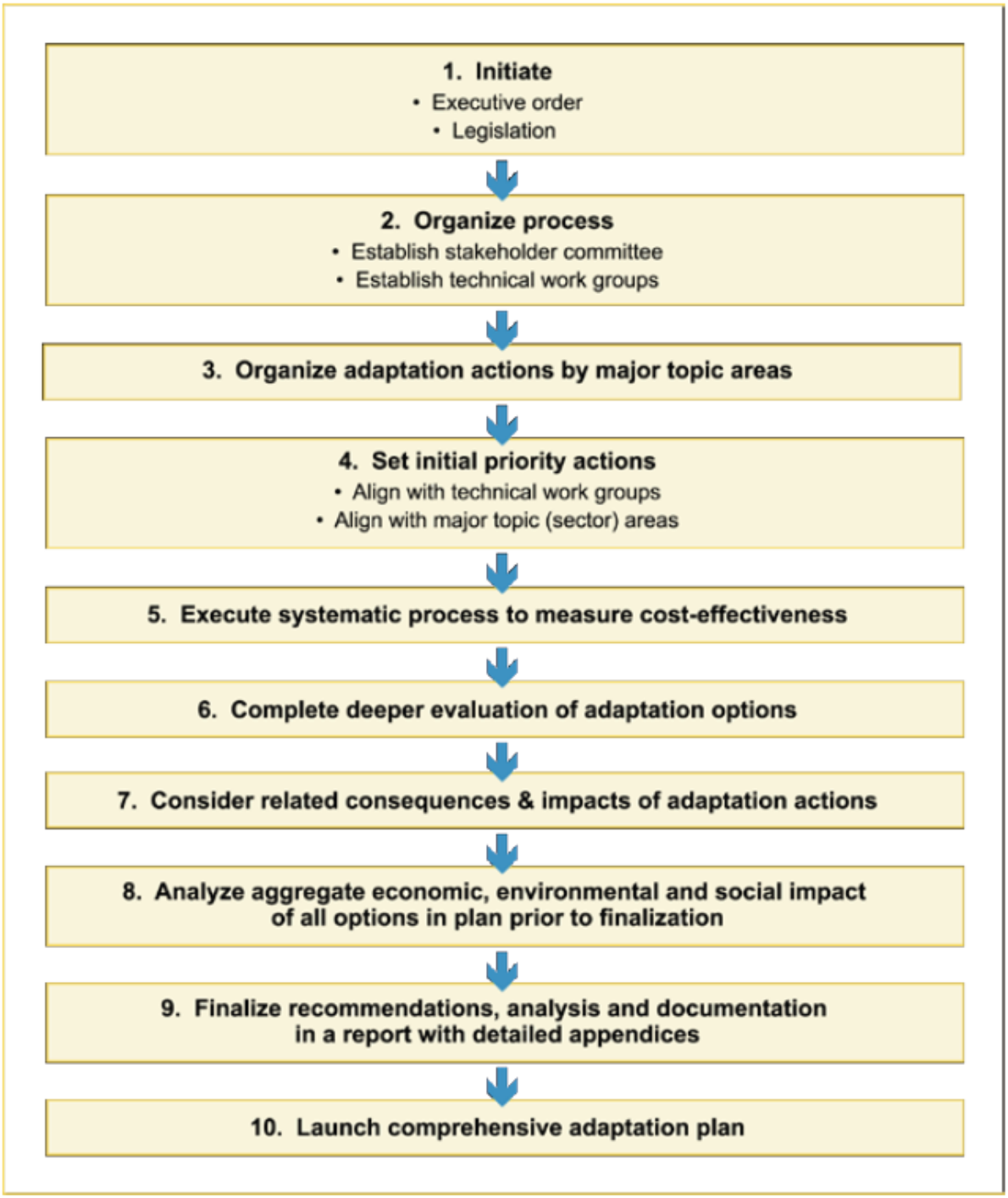
MILESTONE 5: Measure your progress and update your plan (Chapter 12)
- ☐ Develop and track measures of resilience
- ☐ Update your plan

ICLEI is also in the process of supplementing this guide with an online toolkit known as ADAPT: Adaptation Database and Planning Tool.[45] Based on the same Milestones as the printed guide, ADAPT is meant to be a "living version" of the book.[46] By utilizing plug-in data templates, ADAPT should act as a tool to help communities complete their adaptation planning processes. The online format is hoped to be more useful, intuitive, and self-sufficient than the guidebook on its own.[47] Furthermore, it includes automatic, built-in collection of the data entered by governments, resulting in the real-time creation of a database through which ICLEI can track the adaptation activities of its members.[48] This should prove particularly valuable in future evaluation and revision of the program. Currently, two initial modules ("Getting Started" and "Conducting a Resiliency Study") are available; additional modules and a separate online survey tool for community vulnerability assessment are due out in 2012.[49]

The Center for Climate Strategies (CCS) published a step-by-step guide in 2011.[50] While similar to ICLEI's, the CCS checklist is longer and breaks down the decision making steps in greater depth, culminating in the "launch [of the] comprehensive adaptation plan" (see *Figure 2)*[51]. While CCS emphasizes the use of cost-benefit analysis to evaluate potential adaptation options, it does not go into detail regarding how to perform this analysis, with a single example appended. The guide also encourages the development of metrics to rate the predicted effectiveness of actions, with samples included for water and human health sectors. It includes detailed lists of sample adaptation actions across sectors, some case studies, and a resource list of impact assessments on the national, regional, and state levels, as well as across sectors.

Figure 2: CCS planning guide summary

Figure ES-1: CCS Climate Adaptation Planning Process



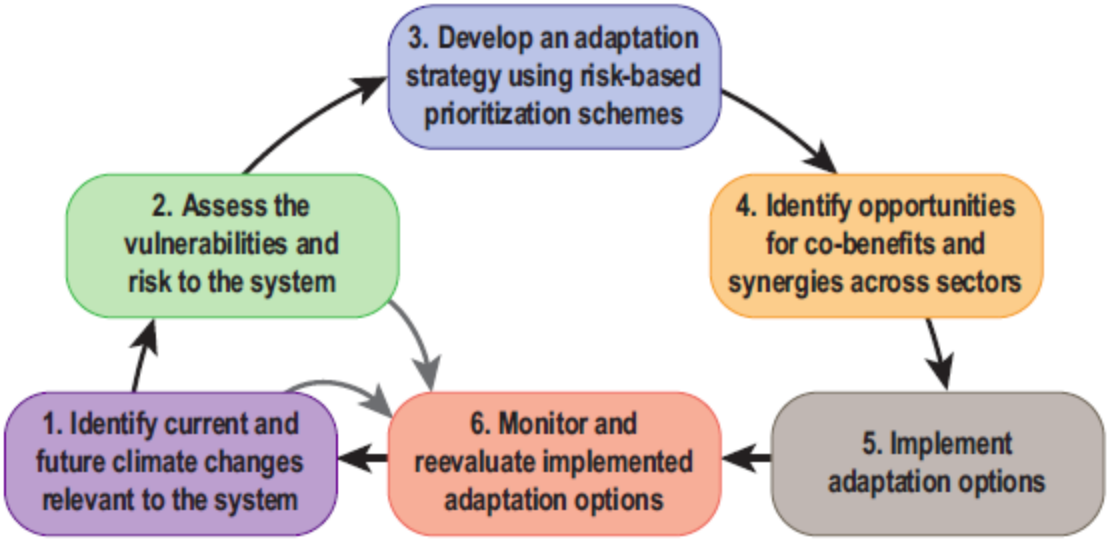
While this guide has a laudable emphasis on decision making processes, it ultimately seems to lack the depth of guidance necessary for communities to complete these analyses.

Furthermore, the very limited discussion of actual plan implementation and evaluation raises questions regarding its potential for concrete impacts on behavior and infrastructure. Given the guide's recent publication, it has yet to be tested thoroughly in the field, though California has cited it as resource for California's climate vulnerability and adaptation initiative.[52]

3.2 Adaptation Principles

Adaptation principles documents provide more generalized guidance and discussion of elements necessary for successful adaptation planning and implementation without going into depth regarding sequential processes or specific resources. Common themes include political leadership, institutional organization, stakeholder involvement, climate change information, setting goals, appropriate use of decision analysis techniques, explicit consideration of barriers and incentives to adaptation, funding for adaptation, technology development and diffusion, adaptation research, and means of monitoring, evaluation, and revision.[53] The 2010 National Research Council report on *Adapting to the Impacts of Climate Change* lays out a sequence of actions similar to ICLEI's Five Milestones, though gives less guidance regarding their completion (see *Figure 3*) [54].

Figure 3: NRC Adaptation planning process summary



Adaptation principles guides have the advantage of generalizability; any government body should be able to incorporate the principles they list into adaptation planning and implementation efforts. However, this general nature likely makes these documents less directly practical than step-by-step guides due to the extra effort required by the planning body. The

criteria adaptation principles guides convey would likely be a good basis for evaluating adaptation planning processes or developing new step-by-step guides.

3.3 Examples and Resources

Guides in this third category in some ways serve as hybrids of the preceding two types. Examples and resources documents discuss more general community needs for adaptation in their introductions and then provide extensive case studies and resource lists to serve as helpful material for communities in various stages of the adaptation planning and implementation process. The Institute for Sustainable Communities' 2010 *Promising Practices in Adaptation and Resilience* categorizes its case studies into "models for adaptation planning," "getting commitment on climate adaptation," "bolstering resilience by integrating adaptation into local planning and operations," and "cross-jurisdictional collaboration."[55] Its resource lists address adaptation planning, risk assessments, adaptation strategies, and getting a commitment to adaptation.[56] The Center for Clean Air Policy encourages communities to *Ask the Climate Question: Adapting to Climate Change Impacts in Urban Regions*.[57] Notable resources include a table of best practices to address adaptation planning challenges, with examples from Urban Leaders Adaptation Initiative communities, and a list of

Box 2: CCAP Federal Policy Recommendations

- Provide **actionable science** that is accessible, accurate and relevant to local needs.
- **Refine models** used most at the local level (climate and hydrologic models), aid regions in filling in data gaps and invest in next-generation computers for more accurate modeling.
- Expand the **Regional Integrated Sciences and Assessments** (RISA) program.
- Create a **climate extension services** to provide local governments with technical assistance on implementing adaptation solutions.
- Facilitate **dialogue** among cities, counties and states on best practices in adaptation planning and implementation.
- Expand programs that encourage **proactive, pre-disaster adaptation** like the Hazard Mitigation Grant program.
- Allocate national **cap-and-trade allowance value** for adaptation efforts.
- **Promote national understanding and awareness** of the importance of adaptation measures by developing communications and outreach materials.
- "**Ask the Climate Question**" by integrating adaptation concerns into all local, state and national decision-making processes.

(*emphasis theirs*)

specific federal policy recommendations (see *Box 2*) [58].

Online adaptation information and case study databases also fall within this category. The Climate Adaptation Knowledge Exchange (CAKE)[59] and Georgetown Climate Center Adaptation Clearinghouse[60] serve as compendia of adaptation information, searchable by sectors, impacts, policy category, policy options, resource types, jurisdictions, author type, and specific locations. Resource types include adaptation plans, agency guidance, assessments (economic, impact, risk, vulnerability, guidance), best management practices, case studies, and climate science. The databases highlight leading organizations and exemplary resources, and track state and local adaptation plans and relevant legislation.

These guides have the advantage of pulling key resources and examples from both step-by-step and adaptation principles guides. However, they neither provide the detailed guidance of step-by-step guides nor the depth of analysis of adaptation principles guides. Therefore, they are likely ideal as supplementary to either of the other types.

3.4 Guide evaluation

Previous adaptation guidebook evaluation has been descriptive in nature. Both the Heinz Center for Science, Economics, and the Environment and Preston et. al. established checklists to rate guidebooks based on their inclusion of various criteria including applicability to stakeholders, goal-setting, stock-taking, decision-making, implementation, and evaluation.[61] Both include the ICLEI guidebook, which scores relatively high; neither includes the specific adaptation principles and examples and resources guides considered in this report, but based on the criteria both of these latter categories would likely score lower than detailed step-by-step guides.

When interviewees were asked to propose criteria for evaluating guides, they suggested comparing the quality and depth of information, detail of methodological guidance, and ease of implementation for governing bodies.[62] Generally, plug-in templates such as ICLEI's ADAPT tool are considered easier to use than detailed guides; the World Bank reports that even the simplest guides generally require six months to a year of work and significant expenditures to complete.[63] However, it is important to consider what quality of planning and implementation is lost due to simplification.[64] Box 3 synthesizes a number of key questions that could be used as criteria in the evaluation of adaptation guides.[65, 66, 67]

While these questions could be applied to each of the adaptation guides surveyed for this report, a number of practitioners suggested that direct evaluation of guides may not be worthwhile given the wide range of government bodies that may serve as audiences for the guides.[68] Despite the purported broad applicability of the guides, differences between communities and the scope of adaptation planning needs between local, regional, state, and federal jurisdictions significantly alters the process.[69] The capacity of the government body can also significantly impact its ability to plan and implement adaptation actions. For example, most Native American tribes are severely limited in their resources to address adaptation, while the Swinomish tribe of western Washington was able to create a very thorough plan thanks to federal government support.[70] The effectiveness of an adaptation guide ultimately depends on how it is implemented,[71] which is in turn related to community resources. While there is a need for consistent guidelines and monitoring tools, local circumstances must be taken into account during evaluation.[72]

Box 3: Evaluation of Adaptation Planning Guides

1. Is locally-specific information available as part of the guide, or do communities need to find and analyze such information on their own?
2. What methodology is included to guide climate risk assessment for local systems and conditions?
3. What decision making criteria is included to overcome uncertainty and conflicting information to allow for action?
    a. Does the guide emphasize the evolution of knowledge as part of adaptive management?
    b. Is evaluation encouraged of both action effectiveness and the quality of predictions upon which decisions were made?
    c. Is collaboration between outside and local experts encouraged to overcome uncertainty?
4. Does the guide consider local policy and political circumstances?
5. What is the desired outcome for different stakeholders using the guide and what type of guidance is most likely to reach the outcomes for each?

Therefore, additional descriptive comparison of planning guides such as the Heinz and Preston reports may be more useful to communities than direct evaluation. While some description is provided above and in Appendix 2 of this report, future work could include a more

systematic comparison, as well as a user-friendly selection tool for communities to find the most appropriate guide(s) to meet their needs (see Conclusion).

4 Current Practices in Adaptation Planning and Implementation

Despite the potential hurdles, many government entities across the country and the globe have undertaken adaptation planning processes in recent years. Given the broad range of community circumstances and capacity and the lack of centralized guidance, the resulting adaptation plans vary widely in their focus and depth. Preston and Ford each set out to perform systematic evaluations of a sample of these plans. Both concluded that the current generation of adaptation plans is fairly weak, particularly given the assumed high capacity of the developed countries in which the plans were produced.[73] Preston rated plans at 16-61% of the maximum score, with an average of 37%.[74] He found that communities tended to focus on the need for capacity-building before taking concrete adaptation actions, emphasizing the importance of more accessible information and tools to overcome uncertainty.[75] Communities would also benefit from stronger connections to existing governance structures and resources through increased mainstreaming of adaptation planning (see Keene example, below).[76]

ICLEI's survey of member adaptation practices indicated that most communities are in the earliest stages of adaptation planning, with 44% in the "contemplation" phase, 18% involved in "preliminary planning," 19% in more concrete "strategic planning," and 18% actually carrying out "implementation."[77] These results were reflected in the comments of multiple interviewees, who perceive adaptation practices as largely restricted to the planning stages, with limited implementation and even less evaluation.[78] This indicates the current importance of focusing on the quality of adaptation planning processes, since little information is currently available regarding outcomes (see Section 5 for additional discussion); however, monitoring and evaluation of the implementation that is occurring can help create valuable lessons for communities at earlier planning stages.

Below, two distinct government approaches to local adaptation planning and implementation are presented as case studies. These examples emphasize two potential strategies to increase the effectiveness of adaptation planning and implementation: Keene, NH prioritized the mainstreaming of its adaptation plan into its community master plan, while the Southeast

Florida Regional Climate Change Compact built coalitions between multiple counties to aggregate community needs and tap into larger resource bases.

4.1 Keene, NH

Keene, New Hampshire is a small New England community (population: 22,834[79]) that built on a strong resource network to create a thorough adaptation plan in 2007 and then integrate that plan into the community master plan in 2010. Having joined ICLEI's Cities for Climate Protection mitigation program in 2000, Keene formed a strong track record of mitigation activity and a partnership with ICLEI that led to its becoming a pilot city for the Climate Resilient Communities adaptation program in 2007.[80] Keene's adaptation plan was therefore developed in parallel with ICLEI's adaptation guidebook, with Keene sharing needs and feedback for the Five Milestone process while ICLEI helped to provide additional capacity to the planning process.[81] Keene also benefitted from a partnership with the University of New Hampshire and the Union of Concerned Scientists, both of which helped to provide and analyze climate impact projection data for the Keene area.[82]

In addition to building on Keene's mitigation efforts, the adaptation plan was developed in response to concerns over increased vulnerability to extreme weather events such as significant floods in 2005.[83] The planning process was led by a Climate Resilient Communities (CRC) committee consisting of the Mayor, City Manager, department heads, City Council members, representatives from the college community, Cities for Climate Protection committee, Southwest Regional Planning Commission, and public health stakeholders.[84] Following

Figure 4: Keene's Identified Vulnerable Sectors and Subsectors

Table 1: Keene's Identified Vulnerable Sectors and Subsectors

Built Environment

- Buildings & Development
- Transportation Infrastructure
- Stormwater Infrastructure
- Energy Systems

Natural Environment

- Wetlands
- Groundwater
- Agriculture

Social Environment

- Economy
- Public Health
- Emergency Services

the principles of the first three steps laid out in the Five Milestones, the CRC committee conducted a climate resiliency study, developed a climate resilient action plan, and laid out recommendations to implement that plan.[85] This process included the identification of key risks for Keene (see *Figure 4*)[86], creating a ranking scale to prioritize adaptation challenges and responses, and setting goals, targets, and performance measure for each adaptation action. Many of these actions were designed to dovetail with existing climate mitigation strategies, which Keene continues to prioritize and sees as complementary to adaptation.[87]

In identifying concrete steps to implement the adaptation plan, Keene expressed an up-front goal of incorporating its adaptation plan into its upcoming master plan,[88] setting the stage for the mainstreaming of its adaptation recommendations: "Perhaps most importantly, implementing this plan will require a change of focus within City Government by evaluating and making changes to policy, procedures, and operations through a 'Climate Lens.' "[89] These goals were played out in the 2010 Master Plan, which is built around the central tenet of long-term sustainability.[90] The Plan's introduction specifically and deliberately includes climate adaptation as a key goal, highlighting its incorporation of 67 action items from the adaptation plan.[91] These include measures such as the reduction of impervious surfaces in parking structures, replacing vulnerable storm water infrastructure, and mandating long-lasting green building technologies.[92]

The implementation of these measures is currently in progress, though formal monitoring and evaluation of their effectiveness is still limited and is not likely to be completed until the master plan revision process for 2020.[93] It is clear, however, that Keene considers the mainstreaming of its adaptation plan into its master plan to be an essential component of its success. While Keene does not provide explicit guidance for other communities to mainstream adaptation planning, the adaptation report does include a number of lessons learned from the adaptation planning process, including the importance of sufficient regular meetings, the involvement of climate scientists, deliberate prioritization of vulnerabilities, and clear definition and goals for the process, such as providing material for a master plan.[94]

4.2 Southeast Florida Regional Climate Change Compact

The Southeast Florida Regional Climate Change Compact represents adaptation planning at a very different scale than for Keene, with the Compact encompassing four counties (Miami-Dade, Broward, Monroe, Palm Beach) with 5.6 million residents, 30% of Florida's population.[95]

The Compact's strategy illustrates successful aggregation of local concerns to pool resources and maximize impact while maintaining a focus on local adaptation needs. The Compact was initiated in 2009 by southeast Florida county officials with the goal of "Coordinated and collective action on [climate change], the defining issue for Southeast Florida for the 21st Century, [to] best serve the citizens of the region."[96] It established a Regional Climate Team with the objective of creating a Southeast Florida Regional Climate Change Action Plan. This plan would provide consistent information regarding the risks of climate change for southeast Florida and suggest strategies for coordinated mitigation and adaptation approaches to reduce these risks.[97]

The resulting Draft Action Plan was released at the December 2011 Compact Summit. It provides vulnerability information, including regionally-consistent methodologies for mapping sea-level rise impacts which had previously been subject to conflicting projections by multiple institutions.[98] It also expresses a mainstreaming goal of "integrating climate adaptation and mitigation into existing systems and to develop a plan that can be implemented through existing local and regional organizations."[99] The Draft Plan emphasizes the designation of "adaptation action areas" that are particularly vulnerable to climate change impacts as targets of state and federal adaptation support, and the Compact has successfully lobbied for a Florida state bill to do so.[100] The Draft Plan highlights 100 concrete adaptation and mitigation actions which are divided into six actionable recommendation areas (see *Box 4*) [101]. It also outlines goals to include an "implementation matrix" to be integrated into the final plan, along with progress indicators for monitoring and evaluation.[102]

Box 4: Southeast Florida Regional Climate Change Draft Action Plan Actionable Recommendation Areas

1. Sustainable community and transportation planning
2. Water supply, management, and infrastructure
3. Risk reduction and emergency management
4. Energy and fuel
5. Natural systems and agriculture
6. Outreach and public policy

The Compact is particularly notable as an example of potential compromise between top-down and bottom-up needs of successful adaptation planning. By combining the resources of 127 municipalities across four counties, the Compact greatly increases its leverage. One of its primary goals has been state and

federal level policy advocacy to promote support for climate mitigation and adaptation action.[103] Not only does the Compact serve as a unified voice to the federal government, it acts as a conduit for federal adaptation guidance and support. The Compact also results in significantly increased capacity to address key adaptation information and planning needs, as illustrated by the development of a common sea-level rise projection for the region. While it is important for the Compact to maintain awareness of the more local needs of its member communities, careful identification of common concerns seems to have resulted in a successful balance.[104]

5 Evaluation of Adaptation Planning and Implementation

Vigorous monitoring and evaluation is a key element that is currently missing from each of the preceding examples of adaptation planning. This deficiency was a common theme raised by interviewees. As stated by Preston, "A systematic approach to monitoring and evaluation for climate change adaptation has yet to emerge, and the capacity to undertake such monitoring and evaluation and incorporate it into adaptation policy is lacking."[105] This deficiency is largely related to the nascent character of the adaptation field; given that most communities are at best in the earliest stages of adaptation planning, they simply lack an implemented program to monitor and evaluate. Furthermore, the lack of coordination between adaptation practitioners makes it more difficult to develop consistent metrics of evaluation. This also relates to the highly local nature of adaptation, which by necessity will vary from community to community. In this context, there is significant uncertainty regarding how to best frame evaluation of adaptation activities and choose appropriate metrics to do so.[106]

Despite these hurdles, there is a significant body of literature on potential climate change adaptation monitoring and evaluation strategies, particularly in the context of international development. One key theme raised by these papers is the distinction between adaptation processes and outcomes. While many traditional evaluation methods focus on the end results of a process, Villanueva suggests that additional consideration of how these outcomes are reached is particularly important for climate adaptation.[107] This emphasis fits the early stages of most communities' progress in adaptation planning (see Section 4). EPA's approach to adaptation evaluation also prioritizes process-side analysis (See Section 6.4). By definition, adaptation is an iterative process that allows for continuous learning and adjustment to changing inputs and circumstances.[108] If climate adaptation planning is guided by a fixed approach which does not

continually respond to changes in climate, climate impacts, and natural and human systems, it is much less likely to be effective. Evaluation of the adaptation planning and implementation processes themselves therefore present opportunities to examine how adaptive capacity is developed and identify leverage points to increase its development as a key adaptation need.[109] Villanueva proposes a five-step framework to ensure effective process monitoring and evaluation based on the principles of Adaptive, Dynamic, Active, Participatory, and Thorough (ADAPT; see *Box 5*) [110].

Box 5: ADAPT Framework and Indicators

Adaptive learning emphasizes the need for methodological flexibility and triangulation…to dynamic and heterogenous local conditions	Indicators reflect possibility of changing conditions
Dynamic monitoring establishes dynamic baselines, which provides real time feedback to inform practice	Indicators capture the way processes are changing
Active in understanding the social, cultural and personal issues such as values, confidence, motivation, risks, and perception	Indicators capture actions rather than states
Participatory approach in the monitoring and evaluation process of those with a stake in the program	Indicators are developed by and with those affected by interventions
Thorough capture of the wider operational environment, accounts for underlying causes of vulnerability	Indicators include maladaptation indications and capture how, or not, the intervention addresses the underlying causes of vulnerability

In addition to process design, Spearman emphasizes the importance of considering the context of adaptation activities, the diversity of inputs to the program design, and the underlying assumptions behind an adaptation program in designing a monitoring and evaluation system for that program.[111] These considerations help account for differences in local needs and circumstances, yet increase the challenge of developing a universal evaluation program. It is likely that monitoring and evaluation, like adaptation planning itself, can be guided through common themes yet ultimately requires customized application at the local level, again raising the challenges of balancing top-down resources with bottom-up needs.

Though these lessons were formulated in the context of international development, they should be applicable to US adaptation programs, as well. Larger scale, top-down adaptation initiatives such as in Chicago and New York City have been more focused on concrete outputs such as numbers of trees planted or alleys made permeable.[112] In contrast, smaller, bottom-up efforts spearheaded by non-profits such as Clean Air Cool Planet have emphasized the degree of awareness and utilization of a given adaptation planning framework, with less focus on outcomes.[113] Despite its potential benefits, in many ways mainstreaming makes evaluation of discreet results more difficult because it is harder to separate the outcomes of adaptation planning from general community planning and operations. One possibility to address these diverse challenges is to look for indicators of a broader "culture of adaptability" that can readily employ adaptive management techniques to respond to continually changing circumstances.[114] A potential baseline for such a metric is broad indication of resilience: how long does it take for a community to return to normal after a given weather event?[115] While such a framework places additional onus on the community to define a "normal," it may allow for a more universal standard to be customized at the local scale.

It is important to recognize that effective evaluation is not only important to improve the outcomes of climate adaptation, but also to help generate support for investment in adaptation activities today and in the future.[116] Particularly in a restricted economy, justifying investments with averted future costs is often necessary to drive government action.[117] The EPA is currently developing a literature synthesis of existing estimates of adaptation costs for different sectors in the US (see Section 6.4 below) which could help inform investment decisions.[118] Monitoring and evaluation of both monetary and substantive results on the "back end" can also help facilitate "front end" decisions and reduce uncertainty.[119]

6 Climate Change Adaptation in Federal Agencies: The Environmental Protection Agency

While climate change adaptation must ultimately occur at the local level, federal agencies play an important role in driving progress towards climate resilience and must also address direct vulnerabilities to climate change. This section addresses actions taken by the Environmental Protection Agency which, while no means alone in its efforts, has demonstrated leadership in the

federal response to climate change. EPA activity corresponds to the four preceding section subjects, providing an effective case study of the climate change adaptation process.

6.1 Needs

The EPA, like all federal agencies, is obligated by the CEQ to prepare a climate change adaptation plan by June 2012.[120] Beyond this mandate, however, the EPA has expressed significant concern over the potential impacts of climate change to its core mission,[121] recognizing that "many of the outcomes EPA is working to attain are sensitive to weather and climate. Consequently, every action EPA takes, including promulgating regulations and implementing programs, should take these fluctuations into consideration."[122] Therefore, the EPA is working to strengthen its understanding of and ability to provide services related to climate adaptation. As part of this initiative, EPA is reaching out to other federal agencies to identify where resources are available and how they can be shared most productively.[123] The agency is also working to identify common resource needs such as climate scenarios at more detailed resolutions.[124] Beyond the federal government, the EPA held a series of round table conversations with states and tribes in 2011 to help gauge the needs of state, local, and tribal governments that depend on EPA support.[125] These needs were enumerated in Section 2 of this report. In conducting this research, EPA hopes to answer the question of what it takes to adapt effectively to climate change in local places and what barriers currently exist to prevent this.[126] By sharing information contained in this report, the NCA can help EPA and other agencies address these needs.

6.2 Guides

The EPA has created adaptation planning and implementation guidance similar to that discussed in Section 3 of this report. As part of a cooperative agreement with the EPA, the Institute for Tribal Environmental Professionals composed a *Tribal Climate Change Adaptation Plan Template* to assist tribal communities in planning for climate change.[127] Designed for ease of use, the Template is ready for tribes to fill in, with guidance on content and formatting. When complete, it provides an overview of local climate impacts and vulnerability, a list of potential goals and actions, and a plan to implement these actions. It assumes that tribes have already completed a climate vulnerability analysis, though the source of this is unclear in the Template. Links to useful sources are embedded in each section. Overall, this step-by-step guide is very

straightforward and user-friendly, but includes little discussion of the resources necessary for effective implementation and evaluation.

An additional resource offered by the EPA is the *Climate Resilience Evaluation and Awareness Tool* (CREAT) computer program designed to assist drinking and wastewater utilities assess and respond to climate change risks.[128] This step-by-step guide bases risk analysis on user-entered utility data and regional project-based downscaled climate projections, and is updated over time to reflect new information. It then provides a list of appropriate adaptation strategies and cost evaluation to inform user decisions.

The EPA is also in the process of updating its climate change website and will be providing information on regional and sectoral adaptation efforts in the new version due out in 2012.[129]

6.3 Plans

The EPA has mainstreamed climate change adaptation considerations into a number of its planning initiatives, starting with its Fiscal Year 2011-2015 Strategic Plan. The introduction states that "climate change must be considered and integrated into all aspects of our work."[130] The Plan goes on to identify three strategic measures specific to climate adaptation goals (see *evaluation* below).[131] A June 2, 2011 *Policy Statement on Climate Change Adaptation* builds on the Strategic Plan by reiterating the importance of climate change to EPA's mission and the need to incorporate climate impact considerations across the agency.[132] It calls for the creation and implementation of an agency-wide adaptation plan that will "integrate climate adaptation into the agency's programs, policies, rules and operations."[133] Furthermore, it requires each national program office and regional offices to create implementation plans to carry out the goals of the national plan.[134] The statement outlines nine specific requirements to ensure the effectiveness of this initiative, including strategic, annual performance measures for evaluating progress and continuous monitoring and evaluation of efforts to adapt to climate change that can lead to necessary adjustments.[135]

Individual EPA programs are already in the process of planning climate change adaptations. The National Water Program, for example, recently released an update to the *National Water Program Strategy: Response to Climate Change*.[136] The update identifies a number of existing EPA-supported programs to facilitate water-related adaptation and affirms

the goal of "adapting implementation of core water programs to maintain and improve program effectiveness in the context of a changing climate."[137] To achieve these goals, the update includes 26 new Key Actions in five categories:[138]

1. Develop data to adapt to climate change
2. Develop analytic tools
3. Plan for extreme water events
4. Increase watershed sustainability and resilience
5. Strengthen partnerships

6.4 Evaluation

Some of EPA's most significant progress has come in the development of tools to monitor and evaluate the effectiveness of adaptation processes and actions. As referenced in Section 5, EPA is in the process of completing a literature synthesis of existing adaptation cost estimates for the US.[139] In regard to EPA's internal adaptation policy goals, EPA is gauging progress by measuring changes in knowledge, behavior, and physical state, or the extent to which EPA action outcomes are reflecting consideration of climate change impacts.[140]

These general metrics relate to the three specific strategic measures included in the 2010 Strategic Plan (see *Box 6*)[141]. To encourage mainstreaming of adaptation efforts and build capacity based on the levers available to EPA to influence action, the agency is striving to integrate adaptation planning into five major scientific models or tools, five major rules or regulations, and five financial mechanisms, such as grants to local bodies.[142] Also known as "tools, rules, and pools," these performance measures can be monitored by counting how many models, rules, and grants demonstrate adaptation planning

Box 6: EPA Climate Adaptation Strategic Measures

- By 2015, EPA will integrate climate change science trend and scenario information into five major scientific models and/or decision-support tools used in implementing Agency environmental management programs to further EPA's mission, consistent with existing authorities (preference for one related to air quality, water quality, cleanup programs, and chemical safety).
- By 2015, EPA will account for climate change by integrating climate change science trend and scenario information into five rule-making processes to further EPA's mission, consistent with existing authorities (preference for one related to air quality, water quality, cleanup programs, and chemical safety).
- By 2015, EPA will build resilience to climate change by integrating considerations of climate change impacts and adaptive measures into five major grant, loan, contract, or technical assistance programs to further EPA's mission, consistent with existing authorities (preference for one related to air quality, water quality, cleanup programs, and scientific research).

considerations.[143] The CREAT model is an example of such a tool. Upcoming major water regulations are expected to integrate adaptation concerns, while the "rules" category is likely to expand to broader action development processes such as state-wide permits.[144] On October 18, 2011 a memo was sent to grant-making authorities at EPA requesting that competitive grants include adaptation evaluation criteria when appropriate, such as explaining how grantee action will have direct or indirect impacts on adaptation capacity.[145] These performance measures are tracked by the Office of Policy and the Chief Financial Manager, which are currently in the process of developing mechanisms to query programs and record results.[146] This evaluation will lead to annual revisions in grant guidelines; a listing of grant programs and recipients with adaptation considerations should be available at the end of fiscal year 2012.[147] Within three years, data on the larger "pool" program will have been collected and evaluated to gauge the outcomes of the adaptation integration initiative.[148]

Like the evaluation literature (see Section 5), EPA's Evaluation Support Division (ESD) within the Office of Strategic Environmental Management has distinguished process-based from outcome-based evaluation of adaptation efforts, thus far prioritizing the former for federal adaptation planning.[149] Two evaluation plans were developed to assess the effectiveness of the federal adaptation planning process. The first was designed to evaluate application of the 2010 Federal Agency Climate Change Adaptation Workgroup Flexible Framework to help agencies begin the adaptation planning process by increasing awareness, identify vulnerabilities, and provide guidance for the design and implementation of adaptation measures to increase agency adaptive capacity.[150] The plan proposed a series of questions which could be administered to pilot program managers to evaluate the framework's applicability, ease of implementation, and effectiveness across federal agencies. The evaluation could be administered in two stages: a shorter-term one to address utility and a longer-term one to address implementation and effectiveness. This latter stage could also include evaluation of pilot program efforts and the conditions in which the framework was administered to draw lessons for potential broader application.[151]

The second evaluation plan from spring 2011 proposed an updated analysis of the continuing federal agency adaptation planning process. It would assess a series of Climate Change Adaptation Workshops for quality and content, develop case studies of agency planning approaches to facilitate lessons learned, evaluate the state of plan development to gauge the

effectiveness of instructions, and measure the implementation of adaptation actions to determine the extent of implementation and results.[152]

An additional proposal from summer 2011 suggested looking more closely at local adaptation processes and needs to help EPA determine how to support these actions. The ESD compiled a list of potential partner communities and organizations to gauge adaptation planning across a number of categories: communities with fully developed adaptation plans, communities whose plans and follow-up involve some degree of evaluation, organizations which provide community adaptation planning guidance, communities emphasizing outreach in their adaptation processes, and businesses which have begun addressing climate adaptation.[153]

However, none of these three evaluation initiatives have been fully completed,[154] suggesting a current lack of capacity in EPA's ESD; staff expressed interest in continuing with this work, but a lack of time and resources to complete it.[155] Given the paucity of effective adaptation planning and implementation evaluation, prioritizing this work could be valuable for both the EPA and the adaptation community as a whole. The ESD has been involved in drafting sections of the 2012 EPA adaptation plan for the CEQ that will discuss measurement and evaluation techniques, including specific performance targets.[156] These products could help bring attention to ESD's efforts and garner additional administrative support.

The EPA National Water Program (NWP) has also made progress in developing adaptation planning and implementation process assessments which could be applied across federal agencies working towards CEQ's adaptation initiative. NWP has developed a matrix to rate progress in "preparation, initiating, research and discovery, assessment, response development, implementing, mainstreaming, and monitoring and review" of federal adaptation initiatives.[157] The matrix includes an explanation and success indicators for each step, and suggests reporting the degree of achievement for each phase in the process regarding agency-specific adaptation goals, all of which can be entered into an intuitive spreadsheet template.[158] NWP indicates that the matrix could be integrated into the review process for EPA program and federal agency annual plans, budgets, and internal and external progress reports, thus further encouraging the mainstreaming of adaptation planning and public awareness.[159] Together with the ESD plans, this effort could go a long way towards standardizing the evaluation of federal agency progress towards effective adaptation.

7 Conclusions: Key Adaptation Tasks and Resources for the 2013 NCA

As is evident from the preceding pages, climate change adaptation is the subject of significant concern and increasing action for government bodies ranging from small communities like Keene, NH to the national Environmental Protection Agency. There is a wealth of available information discussing means of effectively planning for, implementing, and evaluating adaptation practices; the material contained in this report and its appendices merely skims the surface. However, the current lack of structure and guidance to navigate these resources diminish their utility. Thus, a key task for the federal government is to provide systematic organization and linkages between adaptation resources to facilitate action by addressing the informational and decision making needs highlighted by many communities. Numerous interviewees raised the prospect of creating a National Climate Service to embody this support.[160] The www.climate.gov portal currently housed by NOAA could serve as a jumping off point for this initiative, though other options include a National Adaptation Research Program within the US Global Change Research Program or even a public-private partnership.[161] Regardless of its name and institutional structure, this service would ideally serve as an agent to continuously create and monitor information and connect all types of government bodies to resources relevant to their specific needs. This process could include referring governments to more local resource providers (see below). The service should be funded to provide appropriate financial support to communities undertaking adaptation processes and act as a clearinghouse for additional funding sources. It should also coordinate federal adaptation efforts and act as a single voice for federal adaptation initiatives to provide a clear, unified message to stakeholders.

In addition to providing climate adaptation services, the federal government should work to remove barriers to adaptation. Whether laws prohibiting action[162] or systems such as insurance pricing structures that perversely incentivize maladaptive behaviors,[163] as agencies mainstream adaptation concerns part of their task should be to ensure that regulations provide a consistent, productive atmosphere for adaptation planning and implementation.

Given the significant hurdle of balancing top-down resources with unique bottom-up needs specific to local adaptation responses, the federal government should build on opportunities to unite these two approaches. The Southeast Florida Regional Climate Change Compact serves as an excellent example of a method to bridge local needs with broader resources, and could act as a model for similar networks nationwide. The federal government

already has many institutions which can help serve in this bridging capacity, including Regional Integrated Sciences and Assessments (RISAs), USGS Climate Centers, Agricultural Extension services, Sea Grant Extensions, and national laboratories around the country.

Mainstreaming of adaptation planning is also a valuable bridging strategy, as illustrated by Keene's integration of its adaptation plan into its new master plan. Given the pervasive effects of climate and climate change, it makes sense that responding to climate change should be a part of all government branches' planning processes. As most governments have based plans on assumptions of historic climate patterns and status quo, a paradigm shift is necessary to encourage forward-looking planning based on projections of future change. Strong information and stronger services as embodied by the National Climate Service model proposed above can facilitate this process. One challenge brought by mainstreaming is the reduction of obvious actions upon which to base evaluation of adaptation processes. However, if sufficiently flexible adaptation evaluation metrics are developed (see below), they can be integrated into governments' larger evaluation and review procedures.

While there is significant onus on the federal government to act from the top-down, there is also important work that local government bodies can begin performing from the bottom-up now to better interface with future federal resources. One task is the systematic collection of weather and weather impact data.[164] It is important to build a new baseline from which governments can evaluate climate changes and impacts. Monitoring developing weather trends and the quantitative impact of extreme weather events will help determine the effectiveness of future adaptation actions and define the "normal" baseline which resilient communities should strive to maintain.

Government bodies at multiple levels should also begin working to build support for climate adaptation from relevant stakeholders.[165] Such engagement was identified as an important need and is significantly more effective when built from the ground up. Part of this process includes identifying which institutions have jurisdiction over different factors important to integrated adaptation efforts; local, regional, and state governments each have unique power and responsibilities that will need to be coordinated to achieve efficient and effective results.[166] Mapping out these networks now will speed the future implementation of adaptation initiatives.

Coalition-building is a third action that local governments can take today to improve their capacity to manage information and coordinate with top-down resources to better adapt to

climate change.[167] While the Southeast Florida Compact is a climate-specific coalition example, many other existing partnerships could be utilized to build adaptive capacity. These include ICLEI, the Urban Leaders Adaptation Initiative and Climate Leadership Academy,[168] local municipal leagues, the United States Conference of Mayors,[169] and the National Governors Association,[170] as well as a host of important non-governmental organizations.

While this report serves as an initial synthesis of current adaptation needs and resources, additional research is necessary to further develop many of the concepts raised here. Given the conclusion that a menu of adaptation planning guides may be more useful to governments than a single "best" resource, additional support should be provided to help governments navigate the guides that are available. One possible format is a flow chart or dichotomous key that allows governments to answer basic questions about their community size, location, and other needs to reach a recommendation for a guide or guides that are most appropriate for these circumstances.

The relatively weak and uncoordinated field of adaptation monitoring and evaluation calls for significant development of tools which can consistently assess both adaptation processes and outcomes, while remaining relevant to local community circumstances. The metrics created by EPA's ESD and NWP could provide an excellent starting point for further evaluation development. Ultimately, clearer definition of climate resilience in a variety of community settings is necessary to determine the success of adaptation initiatives.

Improving communication channels to quickly share lessons learned and best practices in adaptation between government bodies is a third key area for development. While online databases such as CAKE and the Georgetown Clearinghouse provide a very good start, additional systematic data collection, streamlining, and coordination, as proposed for the National Climate Service model above, is necessary to utilize such compendia to their full extent.

Finally, it is essential to note that adaptation is, by definition, a continually self-adjusting process. Therefore it is not realistic to expect that a single approach to climate change adaptation will continue to be effective into the future. Rather, continual evaluation of new resources and practices and monitoring of results by the federal government through and between Climate Assessments, academic syntheses such as this report, and—most importantly—the practitioners implementing climate adaptations on the ground is crucial to building a truly adaptive society.

8 Appendices

8.1 Appendix 1: Community Adaptation Resource Needs – Annotated Resource List

Hirschfeld, D. & Carmin, J. (2011). *Urban Adaptation in the United States: Lessons from a Global Survey.* ICLEI USA and Massachusetts Institute of Technology Department of Urban Studies and Planning. Chicago, IL: Association of Climate Change Officers.

Summarizes basic results of survey to ICLEI communities regarding adaptation needs. Discusses motivations such as being prepared for future, advancing livability, and reducing hazard impacts. Most communities are gathering information about adaptation planning. Indicates monetary/time resource needs as biggest challenge, communicating as moderate, and scientific resource as lower. Researchers see strengthening communication about importance of adaptation as key means to overcoming other challenges.

ICLEI. (2011). *Resilient Cities 2011: 2nd World Congress on Cities and Adaptation to Climate Change*—Congress Report. Bonn, Germany.

Report of 2011 Resilient Cities conference in Bonn, Germany. Identify 6 key adaptation themes for cities: resilience, assessmenets, planning, implementation, finance, and governance. Discussion of cities' emphasis on assessment for resilience and integration of adaptation into larger planning processes. Evaluate large-scale productivity of actions. Work to coordinate between levels of government while maintaining flexibility and looking for synergies. Case studies from Ho Chi Minh City, Vietnam; Lagos, Nigeria; London, United Kingdom; and Semarang, Indonesia. Mayors' declaration and conclusions for moving forward.

Institute for Sustainable Communities. (2010). *Climate Leadership Academy – Promising Practices in Adaptation and Resilience – A Resource Guide for Local Leaders: Version 1.0.* Produced in partnership with the Center for Clean Air Policy.

Summarizes key conditions and needs of cities to adapt to climate change. Provides a catalog of case studies in adaptation planning, generating commitment for adaptation practices, integration of adaptation into local planning and operational practices. Also catalogs resources for general adaptation information, planning, risk assessment, strategies to address specific climate risks, and generating commitment for adaptation practices.

Leiserowitz, A., Maibach, E., Roser-Renouf, C. & Smith, N. (2011). *Climate change in the*

American Mind: Public support for climate & energy policies in May 2011. Yale University and George Mason University. New Haven, CT: Yale Project on Climate Change Communication. http://environment.yale.edu/climate/files/PolicySupportMay2011.pdf

A significant majority of Americans surveyed respond that it is important to protect local assets from global warming.

Leiserowitz, A., Maibach, E., Roser-Renouf, C., & Smith, N. (2011). *Climate change in the American Mind: Americans' global warming beliefs and attitudes in May 2011.* Yale University and George Mason University. New Haven, CT: Yale Project on Climate Change Communication. http://environment.yale.edu/climate/files/ClimateBeliefsMay2011.pdf

Survey results illustrate moderate concern that global warming will harm selves/other people, especially future generations; harm plants, animals, property; negative impacts from natural disasters and health effects.

Lowe, A., Foster, J., & Winkelman, S. (2009). *Asking the Climate Question: Adapting to Climate Change Impacts in Urban Regions*. Center for Clean Air Policy.

Urban Leaders Adaptation Initiative to encourage consideration of climate issues and provide resource sharing and policy advocacy to encourage progress (larger cities). Lists key resource needs and planning & implementation steps at general level. Includes list of specific federal support actions.Emphasizes importance of "mitigation/adaptation nexus." "Levers of Change" matrix to describe governmental tools/opportunities at local, state, federal level (also private sector).

Theoharides, K., Barnhart, G., & Glick, P. (2009). *Climate Change Adaptation across the Landscape: A survey of federal and state agencies, conservation organizations and academic institutions in the United States*. The Association of Fish and Wildlife Agencies, Defenders of Wildlife, The Nature Conservancy, & The National Wildlife Federation.

Results and analysis of a survey given to federal and state agencies, academic institutions, and NGO's regarding the state of adaptation practices related to conservation and natural resources. Addresses definition of adaptation, best practices, challenges, expenditure, and challenges, outreach, and communication. Results include wide-spread efforts to incorporate adaptation considerations into programming and planning through vulnerability assessments, scenarios, and species-climate models, utilizing partnerships, and developing tools and information. Monitoring strategies emphasize adaptive management techniques; few metrics have been developed yet. Key

challenges include lack of resources, need for place-based techniques, and additional tools and models. In conclusion, utilizing partnerships are identified as a key strategy for efficient progress.

8.2 Appendix 2: Climate Change Adaptation Planning Guides – Annotated Resource List

Bierbaum, R., Holdren, J.P., MacCracken, M., Moss, R.H., & Raven, P.H., et.al. (2007). *Confronting Climate Change: Avoiding the Unmanageable and Managing the Unavoidable*. United Nations Foundation, Sigma Xi.

Provides a thorough overview of the context of adaptation within mitigation and sustainable development on international scale. Describes existing institutions to further adaptation goals and lists technological options for adaptation. Includes adaptation toolkit by sector based on planning/management and technology/R&D methods, with case studies for each.

The Center for Climate Strategies. (2011). *Center for Climate Strategies Adaptation Guidebook: Comprehensive Climate Action.*

Provides a comprehensive guide to adaptation action planning, targeted at state, local, and national government. Breaks adaptation planning down into steps, including identification of options, priorities and decision-making metrics—including cost-effectiveness (though does not go into detail on how to calculate this--one example in Appendix 2); emphasizes the development of metrics rating the effectiveness of adaptation actions to guide planning decisions, though only presents metrics for water and human health sectors, with limited discussion regarding how to apply them (appendix example of criteria to set priorities). Includes comprehensive catalog (appendix 3) of adaptation activities collected from existing actions at the federal, state, and local levels by sector: infrastructure and build environment; natural systems; health and society; economic activities; cross-cutting issues. Also briefly discusses possible intersection between mitigation and adaptation (chpt. 6) and existing government experience with adaptation planning (chpt. 7). No real discussion of how to implement/monitor/revise plan once it's complete.

Economics of Climate Adaptation Working Group. (2009). *Shaping Climate Resilient Development: A Framework for Decision-making.* Economics of Climate Adaptation.

Attempt to address limited quantification of risk and lack of decision support tools. Framework involves identifying risks and calculating magnitude of loss, evaluating response options based on cost-benefit analysis, developing implementation plan to overcome barriers, and monitoring outcomes to inform future decisions. Guidance is very general; even in "methodology guide" appendix geared at decision makers, steps focus only on first three parts of framework and are highly theoretical, assuming ability to

accurately evaluate costs and benefits in monetary terms. Includes test case of hurricane impacts in southeast Florida.

Fussel, H.M. (2007). *Adaptation Planning for Climate Change: concepts, assessment approaches, and key lessons*. Sutain Sci, 2, 265-275. doi: 10.1007/s11625-007-0032-y.

Discusses importance of CC adaptation, interactions between adaptation and mitigation, and characteristics of adaptation processes. Focuses on factors to facilitate effective adaptation, such as problem awareness, availability and information about potential measures, resources, acceptance, and incentives for implementation. Compares hazard-based with vulnerability-based adaptation planning, and value of integrating both methods into integrative approaches leading towards mainstreaming. Summarizes lessons learned for adaptation processes.

ICLEI. (2011). *Adaptation Database and Planning Tool (ADAPT)*. http://www.icleiusa.org/tools/adapt/adaptation-database-and-planning-tool-adapt/

Step-by-step guide with built-in information and templates to customize adaptation plan for a given community. Automatic collection of entered data into online database.

ICLEI. (2008). *Local Government Climate Change Adaptation Toolkit: Cities for Climate Protection Australia Adaptation Initiative*.

Toolkit for city-level climate adaptation planning and management. Includes step-by-step guide and materials, and links to relevant organizations.

Institute for Sustainable Communities. (2010). *Climate Leadership Academy – Promising Practices in Adaptation and Resilience – A Resource Guide for Local Leaders: Version 1.0.* Produced in partnership with the Center for Clean Air Policy.

Summarizes key conditions and needs of cities to adapt to climate change. Provides a catalog of case studies in adaptation planning, generating commitment for adaptation practices, integration of adaptation into local planning and operational practices. Also catalogs resources for general adaptation information, planning, risk assessment, strategies to address specific climate risks, and generating commitment for adaptation practices.

Institute for Tribal Environmental Professionals. (2011). *Tribal Climate Change Adaptation Plan Template*. Northern Arizona University.

Adaptation plan template ready for tribes to fill in. Developed in collaboration with the EPA. Provides guidance on content and formatting, with emphasis on climate impacts, vulnerability and risks, goals and actions, and implementation plan. Assumes tribes have already conducted a climate vulnerability analysis. Includes links to useful sources throughout. User-friendly from template format, but little discussion of resources for implementation.

Lowe, A., Foster, J., & Winkelman, S. (2009). *Asking the Climate Question: Adapting to Climate Change Impacts in Urban Regions.* Center for Clean Air Policy.

Urban Leaders Adaptation Initiative to encourage consideration of climate issues and provide resource sharing and policy advocacy to encourage progress (larger cities). Lists key resource needs and planning & implementation steps at general level. Includes list of specific federal support actions.Emphasizes importance of "mitigation/adaptation nexus." "Levers of Change" matrix to describe governmental tools/opportunities at local, state, federal level (also private sector).

National Research Council. (2010). *Adapting to the Impacts of Climate Change.* America's Climate Choices. National Academies Press. Washington, D.C.

Chapter 4 discusses general barriers to adaptation, including lack of engagement, information, and capacity. Outlines general considerations for adaptation planning, using NYC as case study. Emphasis on risk-management as an effective framework for adaptation decision making; use multiple approaches simultaneously to manage risk. Adaptation planning requirements include leadership and objectives, multi-stakeholder involvement, assessment of vulnerabilities, systematic method of evaluating options including benefits, co-benefits, and adverse impacts, and means of monitoring, evaluation, and revision.

Smith, J.B., Vogel, J.M., & Cromwell, J.E. (2009). *An architecture for government action on adaptation to climate change: An editorial comment*. Climatic Change, 95, 53-61. doi: 10.1007/s10584-009-9623-1.

Outlines key components of governance essential to successful adaptation implementation: political leadership, institutional organization, stakeholder involvement, climate change information, appropriate use of decision analysis techniques, explicit consideration of barriers to adaptation, funding for adaptation, technology development and diffusion, and adaptation research. Emphasizes that "architecture" is not a stepwise guide, but rather criteria to consider regarding the creation of an environment for effective adaptation.

Snover, A.K., Whitely Binder, L., Lopez, J., Willmott, E., Kay, J., Howell, D., & Simmonds, J. (2007). *Preparing for Climate Change: A Guidebook for Local, Regional, and State Governments.* In association with and published by ICLEI- Local Governments for Sustainability, Oakland, CA.

Comprehensive, step-by-step guide for local, regional, and state governments to develop climate adaptation action plans. Includes theory, methods, and list of case studies and resources, including examples of specific adaptation activities by sector.

U.S. Environmental Protection Agency. (2010). *Climate Resilience Evaluation and Awareness Tool.*

Risk assessment and adaptation planning tool for drinking and waste water utility owners. Bases risk analysis on user-entered utility data and regional project-based downscaled climate projections, and is updated over time to reflect new information. Provides list of adaptation strategies and cost evaluation to inform user decisions.

U.S. Environmental Protection Agency. (2006). *Excessive Heat Events Guidebook*. Office of Atmospheric Programs.

Summarizes the consequences, including morbidity and mortality, of excessive heat events. Describes current heat event notification and response programs, including case studies from Philadelphia, Toronto, and Pheonix. Recommends design strategies for heat event notification and response programs, and includes lists of additional information. Strategies can apply to smaller cities.

8.3 Appendix 3: Current Practices in Adaptation Planning and Implementation – Annotated Resource List

Arup. (2011). *Climate Action in Megacities: C40 Cities Baseline and Opportunities*.

Presents survey data from C40 international cities regarding climate change mitigation and adaptation actions. Summarizes adaptation actions to date and future plans, and identifies—but does not detail—potential case studies re: specific activities, including NY effort to evaluate cost-effectiveness of adaptation practices.

Averyt, K., et.al. (2011). *Colorado Climate Preparedness Project: Final Report*. Prepared by the Western Water Assessment for the State of Colorado.

Colorado Climate Preparedness Project summarizes climate impacts, adaptation actions, and options in Colorado (wildlife, water, ecosystems and forests, electricity, agriculture, recreation sectors). Benchmarks against state adaptation plans for Alaska, California, and Maryland.

Boicourt, K. & Johnson, Z.P., eds. (2011). *Comprehensive Strategy for Reducing Maryland's Vulnerability to Climate Change: Phase II – Building societal, economic, and ecological resilience*. Maryland Commission on Climate Change Adaptation and Response and Scientific and Technical Working Groups.

California Natural Resources Agency. (2009). *2009 California Climate Adaptation Strategy: A report to the governor of the State of California in response to Executive Order S-13-2008.*

City of Keene, New Hampshire. (2007). *Adapting to Climate Change: Planning a Climate Resilient Community.* In association with ICLEI: Local Governments for Sustainability.

Thorough local adaptation plan based on ICLEI Climate Resilient Communities model. Includes justification, projections for local impacts, key community vulnerability areas, adaptation opportunities, goals, and targets, and next steps. Also identifies lessons learned regarding adaptation planning process.

City of Keene, New Hampshire. (2010). *Keene Comprehensive Master Plan.*

Plan framed around core principle of sustainability (3-E's). Explicit references to integration of climate change adaptation goals in Resolution of Endorsement and Introduction. Recommends creation of Sustainability Commission. Integrates adaptation actions throughout plan areas, such as transportation infrastructure, stormwater

management, and emergency preparedness. Climate change section highlights 2007 adaptation plan and importance of synergies between adaptation and mitigation.

The City of New York. (2011). *PlaNYC: A greener, greater New York.*

Climate Adaptation Knowledge Exchange (CAKE). http://www.cakex.org/

Cruce, T.L. (2009). *Adaptation Planning: What U.S. States and Localities are Doing.* Pew Center on Global Climate Change.

Summarizes state-level and local-level adaptation planning actions, with summary tables and links to state and local plans (potential case studies).

Cruce, T.L. & Holsinger, H. (2010). *Climate Change Adaptation: What Federal Agencies are Doing.* Pew Center on Global Climate Change.

Summary of federal agency actions related to climate change adaptation, organized by agency.

Georgetown Climate Center Adaptation Clearinghouse. http://www.georgetownclimate.org/adaptation/clearinghouse

Compendium of adaptation information, searchable by sectors, impacts, policy category, policy options, resource types, jurisdictions, author type, and specific locations (map function). Resource types include adaptation plans, agency guidance, assessments (economic, impact, risk, vulnerability, guidance), best management practices, case studies, climate science. Highlights leading organizations and exemplary resources. Tracks state and local adaptation plans, relevant legislation.

ICLEI. (undated). Case Study: *Homer, Alaska's Climate Adaptation Process Despite Uncertainties*.

Identifies key climate impacts, adaptation priorities and strategies for infrastructure, emergency preparedness, and future development, and adaptation-mitigation synergies.

ICLEI. (undated). Case Study: *Institutionalizing Climate Preparedness in Miami-Dade County, Florida.*

Identifies key climate impacts, strategies to adapt while increasing local sustainability, and means of overcoming adaptation barriers.

ICLEI. (undated). Case Study: *Keene, New Hampshire Leading on Climate Preparedness*.

Describes process of forming an adaptation preparedness team, adaptation planning actions and prioritization, and lessons learned.

Massachusetts Executive Office of Energy and Environmental Affairs, Adaptation Advisory Committee. (2011). *Massachusetts Climate Change Adaptation Report*.

Comprehensive discussion of climate change impacts and adaptation strategies for Massachusetts, with focuses on natural resources and habitat, key infrastructure, human health and welfare, local economy and government, and coastal zones and ocean.

New York State Climate Action Council. (2010). *Climate Action Plan Interim Report*.

Office of Planning and Community Development. (2010). *Swinomish Climate Change Initiative: Climate Adaptation Action Plan*. Swinomish Indian Tribal Community.

Perkins, B., Ojima, D., & Corell, R. (2007). *A Survey of Climate Change Adaptation Planning*. The H. John Heinz III Center for Science, Economics, and the Environment.

Surveys and rates adaptation planning guides based on included features, with summary tables. Surveys adaptation plan case studies in cities, and indexes them by sector. Does not go into great depth, but includes significant resource list and could be helpful for screening, though somewhat out of date.

Southeast Florida Regional Climate Compact. (2009).

2009 Compact emphasizes vulnerability of southeast Florida to CC, esp. sea level rise. Discusses importance of both mitigation and adaptation activities. Sets goal of unified policy advocacy to support these efforts at the federal and state level, as well as creation of a Regional Climate Team to create an Action Plan which will include both mitigation and adaptation components.

Southeast Florida Regional Climate Change Compact Counties. (2011). *A Region Responds to a Changing Climate: Draft Regional Climate Change Action Plan.*

Provides background on Compact development process and goals to "integrate climate adaptation and mitigation into existing systems and to develop a plan that can be implemented through existing local and regional organizations." Emphasizes value of regional approach to pool resources and increase consistency (ie: SLR projections). Highlights over 100 action items (including many specific adaptation actions) in 6 planning areas: Sustainable community and transportation planning; Water supply, management, and infrastructure; Risk reduction and emergency management; Energy

and fuel; Natural systems and agriculture; Outreach and public policy. Outlines next steps for formalization of plan, implementation, and evaluation.

U.S. Environmental Protection Agency. (2010). *Fiscal Year 2011-2015 EPA Strategic Plan: Achieving Our Vision*.

Acknowledges potential impact of climate change on EPA's mission and goals and prioritizes consideration of climate mitigation and adaptation across agency programs and goals. Includes explicit measurement goals of incorporating climate change impact consideration into 5 major models/tools, rules, and grants ("pools") by 2015.

U.S. Environmental Protection Agency. (2010). *National Water Program Strategy: Response to Climate Change – Key Action Update for 2010-2011*. Office of Water.

U.S. Environmental Protection Agency. (2011). *Policy Statement on Climate Change Adaptation*.

Outlines EPA's concern regarding the impacts of climate change on its mission and the need to incorporate climate adaptation planning throughout the agency. Designates specific adaptation planning steps to address these concerns, to be coordinated by EPA's senior climate adaptation official.

Water Utility Climate Alliance. (2010). *Decision Support Planning Methods: Incorporating Climate Change Uncertainties into Water Planning*.

White paper discussion of decision-making processes for water utilities given increasing importance of climate impacts. Assumes adaptation is necessary. Compares five decision support planning methods (DSPMs), including a summary chart and case studies for four of five methods.

The White House Council on Environmental Quality. (2011). *Progress Report of the Interagency Climate Change Adaptation Task Force: Federal Actions for a Climate Resilient Nation.*

The White House Council on Environmental Quality. (2010). *Progress Report of the Interagency Climate Change Adaptation Task Force: Recommended Actions in Support of a National Climate Change Adaptation Strategy.*

Provides an update on federal government climate adaptation activities and recommendations for policies to strengthen these activities and the role of the federal government in adaptation planning and implementation. Includes a list of specific adaptation-related activities being carried out by many government agencies (Part 6). Policy goals include increased adaptation information resources, as embodied in the NCA and climate.gov.

8.4 Appendix 4: Evaluation of Adaptation Planning and Implementation – Annotated Resource List

Barron, Eric, et. al. (2005). *Thinking Strategically: The Appropriate Use of Metrics for the Climate Change Science Program*. Committee on Metrics for Global Change Research, Climate Research Committee, National Research Council.

Ford, J.D., Berrang-Ford, L., & Paterson, J. (2011). *A systematic review of observed climate change adaptation in developed nations.* Climatic Change, 106, 327-336. doi: 10.1007/s10584-011-0045-5.

Summarizes a systematic review of academic articles from 2006-2009 with the potential to address adaptation. Narrows 1,741 documents to 39 articles for substantial review. Concludes that reporting on adaptation from developed nations is limited and generally performed by government units, differing by regions; adaptation projects occur most in the transportation, infrastructure, and utilities sectors and are often non-structural; apply to limited populations, involve multiple stakeholders, and are motivated by multiple factors. Includes links to comprehensive article lists and breakdowns.

Hagemann, M., Harvey, B., et. al. (2011). *Guiding Climate Compatible Development: User-oriented analysis of planning tools and methodologies.* Ecofys, IDS.

*Analyzes a broad range of tools and methodologies available to manage both climate mitigation and adaptation, with goal of finding intersection between mitigation, adaptation, and development needs. Concludes that such an intersection does not yet exist, but discusses multiple elements of mitigation-adaptation interaction. Surveys international users and summarizes needs. Evaluates 30 tools in depth, comparing tool focus, linkages, usefulness, geographic scope, policy stages (*little evaluation*), stakeholder involvement, and accessibility. Finds adaptation assessment and process guidance tools to be most useful, with generic geographic and governmental scale, planning focus, goal of stakeholder involvement, and fairly good accessibility. Concludes with options to improve climate compatible development strategies, including stronger integration of mitigation, adaptation, and development tools. Survey findings discuss user needs.*

Hammill, A. & Tanner, T. (2011). *Harmonising Climate Risk Management: Adaptation Screening and Assessment Tools for Development Co-operation.* OECD Environment Working Papers, No. 36, OECD Publishing. http://dx.doi.org/10.1787/5kg706918zvl-en

Survey of climate adaptation tool use in developing countries. Diagrams tool role in planning process. Analyzes user characteristics (often scientists), information use (generally pre-packaged summaries), benefits (resilient development strategies,

awareness-raising, capacity building), limitations (multiple stressors, M&E, resources, partner engagement), opportunities (rationale, common info, common guidance, strategic climate risk management, common M&E framework).

Interagency National Climate Assessment Task Force. (2011). *Valuation Techniques and Metrics for Climate Change Impacts, Adaptations, and Mitigation Options: Methodological Perspectives for the National Climate Assessment.*

Report of workshop addressing opportunities and challenge to evaluate the impacts of climate change and effectiveness of mitigation and adaptation in monetary terms. Includes summaries of valuation method options—including for climate change, relationships between categories of well-being and climate impacts, and discussion of the intersection of mitigation and adaptation.

Kalkstein, L.S., Greene, S., Mills, D.M., & Samenow, J. (2010). *An evaluation of the progress in reducing heat-related human mortality in major U.S. cities*. Natural Hazards. doi: 10.1007/s11069-010-9552-3.

Evaluation of excess heat-related mortality in 40 US cities from 1975-2004. Concludes that while mortality rates have decreased since 1996, estimated rates may change under future climate change and improvements can still be achieved through better excess heat planning and response.

Larsen, P.H., Goldsmith, S., Smith, O., Wilson, M.L., Strzepek, K., Chinowsky, P., & Saylor, B. (2008). *Estimating future costs for Alaska public infrastructure at risk from climate change.* Global Environmental Change, 18, 442-457. doi: 10.1016/j.gloenvcha.2008.03.005.

Evaluates the projected cost of responding to climate change impacts on Alaskan public infrastructure. Finds likely increases of 10-20% over normal wear and tear by 2030, and that adaptation strategies could offset up to 45% of long term costs.

Neumann, J., Hudgens, D., Herter, J., & Martinich, J. (2010). *The economics of adaptation along developed coastlines.* Wiley Climate Change, Vol. 2. doi: 10.1002/wcc.90.

Evaluates likely cost impacts of sea level rise on coastal infrastructure based on EPA sea level rise coastal property model (http://cfpub.epa.gov/crem/knowledge_base/crem_report.cfm?deid=227624). Concludes that, using the model, cost impacts of sea level rise can be evaluated in sufficient detail at a large scale, and these costs are higher than prior estimates, but still lower than the value of coastal property, suggesting that selected adaptation methods can be cost-effective.

Perkins, B., Ojima, D., & Corell, R. (2007). *A Survey of Climate Change Adaptation Planning*. The H. John Heinz III Center for Science, Economics, and the Environment.

Surveys and rates adaptation planning guides based on included features, with summary tables. Surveys adaptation plan case studies in cities, and indexes them by sector. Does not go into great depth, but includes significant resource list and could be helpful for screening, though somewhat out of date.

Preston, B.L., Westaway, R.M., & Yuen, E.J. (2011). *Climate Adaptation Planning in Practice: An evaluation of adaptation plans for three developed nations.* Mitigation and Adaptation Strategies for Global Change, 16, 407-438.

Quantitative evaluation of climate adaptation plans based on criteria identified in adaptation planning guides. Finds that no plans include all of the possible criteria, with few scoring over 50% of possible points. Particular weaknesses include consideration of non-climatic factors and adaptive capacity. Recommends more integrated approach to adaptation planning that involves local stakeholders in planning process.

Prowse, M. & Snilstveit, B. (2009). *Impact Evaluation and Interventions to Address Climate Change: A scoping study*. International Initiative for Impact Evaluation.

Impact evaluation, "analysis that measures the net change in outcomes attributed to a specific program," is an important tool to measure the effectiveness of climate interventions and justify future investments. Looking at CC in developing countries, little effective IE has been performed to date due to a number of challenges, including lack of baselines, indicators, defined success, and long time horizons. IE has been successfully applied in other conservation areas, and has potential for use in CC evaluation, particularly in conjunction with traditional development strategies and metrics ("mainstreaming"). Identifies example methods in agriculture, water resource management, and social protection.

Spearman, M. & McGray, H. (2011) *Making Adaptation Count: Concepts and Options for Monitoring and Evaluation of Climate Change Adaptation*. World Resources Institute, GIZ.

Discusses the significance of adaptation in developing countries, and the importance of monitoring and evaluation (M&E) to track the effectiveness of these efforts and guide future strategies. Emphasizes the importance of context to adaptation and learning, flexibility, and results-based management as principles for its M&E. Lays out a 6-step framework to develop adaptation M&E for adaptation and development practitioners:

describe the adaptation context, identify the contribution to adaptation, form an adaptation hypothesis, create an adaptation theory of change, choose indicators and set a baseline, and use the adaptation M&E system. Concludes that linking M&E systems and acknowledging tradeoffs between them can help strengthen adaptation outcomes. Includes lists of adaptation M&E tools, adaptation tools which incorportate M&E, and frameworks for M&E in appendices.

U.S. Environmental Protection Agency. (2010). *Fiscal Year 2011-2015 EPA Strategic Plan: Achieving Our Vision*.

Acknowledges potential impact of climate change on EPA's mission and goals and prioritizes consideration of climate mitigation and adaptation across agency programs and goals. Includes explicit measurement goals of incorporating climate change impact consideration into 5 major models/tools, rules, and grants ("pools") by 2015.

Villanueva, P.S. (2011). *Learning to ADAPT: Monitoring and evaluation approaches in climate change adaptation and disaster risk reduction – challenges, gaps and ways forward.* Strengthening Climate Resilience.

Not only are adaptation evaluation practices/metrics fairly limited, they tend to focus too much on outcomes of effectiveness and efficiency of adaptation practices. This places constraints on adaptation practices by neglecting the process in favor of the outcomes and missing key opportunities for learning and change along the way: fundamental tenets of adaptation. Proposes alternative ADAPT framework of indicators (Adaptive, Dynamic, Active, Participatory, Thorough) to ensure inclusion of more comprehensive development, learning, and outcome considerations in adaptation evaluation.

8.5 Appendix 5: Interviews

Adams, Steve. Senior Advisor, Climate Adaptation, Institute for Sustainable Communities. 23 November 2011.

Agrawal, Arun. Professor, School of Natural Resources and Environment, University of Michigan. 13 October 2011.

Deangelo, Benjamin. Climate Change Division, U.S. Environmental Protection Agency. 10 November 2011.

Engert, Mikaela. Former Planner, City of Keene Planning Department. Email, 27 November 2011.

Engle, Nathan. American Association for the Advancement of Science Fellow. 27 September 2011.

Filbin, Gerald. Director, Program Support Staff, Office of Environmental Management, U.S. Environmental Protection Agency. 12 October 2011, 14 November 2011.

Foster, Josh. Program Manager, NOAA & DoI NW Regional Climate Science Centers, OCCRI/Oregon State University. Email, 7 November 2011.

Goldstein, Elana. Water Policy Staff, Office of Water, U.S. Environmental Protection Agency. 10 November 2011.

Holland, Brian. Director of Climate Programs, ICLEI – Local Governments for Sustainability USA. 21 November 2011.

Jantarasami, Lesley. Climate Change Division, U.S. Environmental Protection Agency. 10 November 2011.

Johnson, Britta. Evaluation Support Division, U.S. Environmental Protection Agency. 14 November 2011.

Kalafatis, Scott. Graduate Student Research Assistant, School of Natural Resources and Environment, University of Michigan. 15 November 2011.

Perkins, Bill. Climate Change Analyst, Climate Change Division, U.S. Environmental Protection Agency. 20 September 2011, 25 October 2011, 10 November 2011.

Preston, Benjamin. Deputy Director and Theme Leader—Impacts, Adaptation and Vulnerability Science, Climate Change Science Institute, Oak Ridge National Laboratory. 4 November 2011.

Scheraga, Joel. Senior Advisor for Climate Adaptation, Office of the Administrator, Office of Policy, U.S. Environmental Protection Agency. 12 October 2011.

Snover, Amy. Co-director, Climate Impacts Group, JISAO Center for Science in the Earth System, University of Washington. 31 October 2011.

Stults, Melissa. Former Climate Adaptation Program Manager, ICLEI – Local Governments for Sustainability USA. 17 November 2011.

[1] Bierbaum, et. al. (2007)
[2] Lieserowitz, et. al (2011a)
[3] Lieserowitz, et. al (2011)
[4] Cruce (2009)
[5] Preston, et. al. (2011)
[6] Preston, personal communication 11/4/11
[7] ibid
[8] Hirschfeld & Carmin (2011)
[9] ibid
[10] Bierbaum (2010)
[11] ibid
[12] Union of Concerned Scientists (2011)
[13] National Research Council (2010)
[14] ibid
[15] EPA, personal communication 11/10/11
[16] Lowe, et. al. (2009)
[17] ibid
[18] Hirschfeld & Carmin (2011)
[19] City of Keene (2007)
[20] Preston, personal communication 11/4/11
[21] Institute for Sustainable Communities (2010)
[22] Snover, personal communication 10/31/11
[23] Institute for Sustainable Communities (2010)
[24] Economics of Climate Adaptation Working Group (2009)
[25] Institute for Sustainable Communities (2010)
[26] National Climate Adaptation Summit Committee (2010)
[27] Institute for Sustainable Communities (2010)
[28] Theoharides, et.al. (2009)
[29] Lowe, et. al. (2009)
[30] Hirschfeld & Carmin (2011)
[31] ibid
[32] Filbin, personal communication
[33] National Climate Adaptation Summit Committee (2010)
[34] Preston, personal communication
[35] Preston, personal communication
[36] National Climate Adaptation Summit Committee (2010); Institute for Sustainable Communities (2010)
[37] CC Across the Landscape
[38] CAKE, Georgetown
[39] SEFLRCCC
[40] ICLEI/MIT Presentation 2011
[41] Filbin, personal communication 10/12/11
[42] Snover, et. al. (2007)
[43] Snover, et. al. (2007)
[44] Snover, personal communication 10/31/11
[45] ICLEI (2011)
[46] Stults, personal communication 11/17/11
[47] Holland, personal communication11/21/11
[48] Stults, personal communication11/17/11
[49] Holland, personal communication 11/21/11
[50] Center for Climate Strategies (2011)
[51] ibid
[52] http://www.climatestrategies.us/articles/articles/view/46
[53] Smith, et. al. (2009); Fussel (2007); National Research Council (2010)

[54] National Research Council (2010)
[55] Institute for Sustainable Communities (2010)
[56] ibid
[57] Lowe, et. al. (2009)
[58] ibid
[59] Climate Adaptation Knowledge Exchange
[60] Georgetown Climate Center Adaptation Clearinghouse
[61] Perkins, et.al. (2007); Preston, et. al. (2010)
[62] Snover, personal communication 10/31/11
[63] Hammill & Tanner (2011)
[64] Snover, personal communication 10/31/11
[65] ibid
[66] Stults, personal communication 11/17/11
[67] Preston, personal communication 11/4/11
[68] Engert, personal communication 11/27/11; Preston, personal communication 11/4/11; Kalafatis personal communication 11/15/11
[69] Snover, personal communication10/31/11
[70] EPA, personal communication 11/10/11
[71] Preston, personal communication 11/4/11
[72] EPA, personal communication 11/10/11
[73] Preston, et.al (2011); Ford, et.al. (2010)
[74] Preston, et.al (2011)
[75] ibid
[76] ibid
[77] Hirschfeld & Carmin (2011)
[78] Filbin, personal communication 10/12/11; Foster, personal communication 11/7/11; Snover, personal communication 10/31/11; Stults, personal communication11/17/11
[79] City of Keene (2010)
[80] City of Keene (2007)
[81] Engert, personal communication 11/27/11
[82] City of Keene (2007)
[83] ibid
[84] ibid
[85] ibid
[86] ibid
[87] ibid
[88] ibid
[89] ibid
[90] City of Keene (2010)
[91] ibid
[92] ibid
[93] Engert, personal communication 11/27/11
[94] City of Keene (2007)
[95] Southeast Florida Regional Climate Change Compact Counties (2011)
[96] Southeast Florida Regional Climate Compact (2009)
[97] ibid
[98] Southeast Florida Regional Climate Change Compact Counties (2011)
[99] ibid
[100] ibid
[101] ibid
[102] ibid
[103] ibid
[104] Adams, personal communication 11/23/11
[105] Preston, et.al (2011)
[106] Filbin, personal communication 11/14/11

[107] ICLEI (2011)
[108] ibid
[109] ibid
[110] ibid
[111] Spearman & McGray (2011)
[112] ibid
[113] ibid
[114] ibid
[115] ORNL Urban, Infrastructure, and Vulnerability Workshop, 11/10/11
[116] Prowse & Snilstveit (2009)
[117] Adams, personal communication 11/23/11
[118] Perkins, personal communication 9/20/11
[119] Adams, personal communication 11/23/11
[120] The White House Council on Environmental Quality (2010)
[121] U.S. Environmental Protection Agency (2011)
[122] U.S. Environmental Protection Agency (2010a)
[123] Scheraga, personal communication 10/12/11
[124] ibid
[125] Filbin, personal communication 10/12/11
[126] Scheraga, personal communication 10/12/11
[127] Institute for Tribal Environmental Professionals (2011)
[128] U.S. Environmental Protection Agency (2010)
[129] Perkins, personal communication 9/20/11
[130] U.S. Environmental Protection Agency (2010a)
[131] ibid
[132] U.S. Environmental Protection Agency (2011)
[133] ibid
[134] ibid
[135] ibid
[136] U.S. Environmental Protection Agency (2010b)
[137] ibid
[138] ibid
[139] Perkins, personal communication 9/20/11
[140] Scheraga, personal communication 10/12/11
[141] U.S. Environmental Protection Agency (2010a)
[142] Scheraga, personal communication 10/12/11
[143] ibid
[144] Filbin, personal communication 11/14/11
[145] ibid
[146] ibid
[147] ibid
[148] ibid
[149] EPA, personal communication 11/10/11
[150] Johnson, personal communication 11/14/11
[151] ibid
[152] ibid
[153] ibid
[154] ibid
[155] ibid
[156] ibid
[157] Goldstein, personal communication 12/1/11
[158] ibid
[159] ibid
[160] Preston, personal communication 11/4/11; Adams, personal communication 11/23/11
[161] Bierbaum, personal communication 1/9/12

[162] Filbin, personal communication 10/12/11
[163] National Climate Adaptation Summit Committee (2010)
[164] EPA, personal communication 11/10/11
[165] EPA, personal communication 11/10/11; Adams, personal communication 11/23/11
[166] ibid
[167] Preston, personal communication 11/4/11
[168] http://www.iscvt.org/clanetwork/
[169] http://www.usmayors.org/
[170] http://www.nga.org/cms/home.html

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